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I, ANNA MAIJA EVERETT, ACTING TEAM LEADER EXAMINATION SUPPORT & SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 1602 for a patent by ENERGY STORAGE SYSTEMS PTY LTD filed on 13 July 1999.

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Twenty-first day of July 2000

A. M. Everett.

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AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:-

"AN ENERGY STORAGE DEVICE"

The invention is described in the following statement:-

The present invention relates to an energy storage device.

The invention has been developed primarily for high internal resistance batteries and will be described hereinafter with reference to that application. However, the invention is not limited to that particular field of use and is also applicable to other energy storage devices such as primary and secondary batteries whether wet or dry cell, alkaline, Lithium ion, Lithium polymer, Nickel Metal Hydride or Nickel Cadmium.

Dry cell and alkaline batteries, both in primary and secondary form, are used in a wide variety of applications. Primary batteries are once only or disposable batteries, while secondary batteries are rechargeable. Batteries of these kinds are used in mobile and cellular telephones, portable computers, cordless electric power tools, household appliances, cameras, and other mobile devices to name but a few. These form of batteries are preferred as they provide a relatively high energy density and are relatively inexpensive.

The most common disposable batteries are in the form of cylindrical cells, each of which provides a potential of about 1.5 Volts. A number of such cells are generally connected in series to provide the necessary voltage for the device concerned. These cells are specified by size categorisations, which are designated, for example, as N, AAAA, AAA, AA, C and D. Other prismatic forms are also available.

However, these batteries suffer from several limitations including poor accommodation of wide variations in load currents and a low efficiency at high load currents. Accordingly, in circumstances where a constant load current is drawn, such as in a torch, a battery is an ideal source of energy. However, where varying load currents, and particularly high load currents for high power applications are encountered the

battery life becomes compromised. For example, when a power tool, such as an electric drill, is operating at a constant low current to provide a given torque, the battery is efficiently providing the necessary energy requirements. However, should the operator require a higher torque for a short period, a pulse or surge of power will be required. However, the demand for such transitory power requirements is not efficiently provided by a battery. In some drills use is made of adjustable gearing to provide a wider range of available torque.

Similar problems to that foreshadowed above for the drill arise for other devices whether they are toys, electronic games, mobile or cellular phones, portable or laptop computers or the like. In an attempt to address this limitation it has been known to provide a battery having a slightly lower internal resistance. However, this form of battery design compromises the energy density of the resultant battery.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

According to a first aspect of the invention there is provided an energy storage device including:

a housing having two terminals;

an electrochemical device disposed within the housing for providing an electrical potential between the terminals; and

a first capacitor mounted to the housing and connected to the terminals in parallel with the electrochemical device.

Preferably, the device extends about the housing. More preferably, the housing is cylindrical and extends between two opposed axially spaced apart ends, whereby the

ends define respective terminals and the capacitor extends about the housing intermediate the ends.

Preferably also, the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate for allowing charge transfer between the electrodes.

In a preferred form the capacitor is flexible and wound about the housing. In an alternative embodiment, the capacitor is flexible and wound within the housing. In a still further embodiment the capacitor is spirally wound.

Preferably, the electrochemical device is generally cylindrical and extends between two opposed axially spaced apart ends and the first capacitor extends axially away from one of the ends. More preferably, the charge storage device includes a second capacitor which has an aperture for receiving the electrochemical device. Even more preferable, the aperture receives both the electrochemical device and the first capacitor. In one embodiment, the second capacitor is tubular and extends about the first capacitor and the electrochemical device.

According to a second aspect of the invention there is provided an energy storage device including:

a housing having two terminals; and

a first capacitor forming part of the housing and connected to the terminals.

Preferably the housing has a form factor corresponding or being related to battery size designations N, AAAA, AAA, AA, C or D.

Preferably, an electrochemical device is disposed within the housing for providing electrical energy to the terminals.

Preferably, the device extends about the housing. More preferably, the housing is cylindrical and extends between two opposed axially spaced apart ends, whereby the ends define respective terminals and the capacitor extends about the housing intermediate the ends.

Preferably also, the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate for allowing charge transfer between the electrodes.

In a preferred form the capacitor is flexible and wound about the housing. In an alternative embodiment, the capacitor is flexible and wound within the housing. In a still further embodiment the capacitor is spirally wound.

Preferably, the electrochemical device is generally cylindrical and extends between two opposed axially spaced apart ends and the first capacitor extends axially away from one of the ends. More preferably, the energy storage device is of hollow construction with an aperture for receiving the electrochemical device. Even more preferably, the aperture receives both the electrochemical device and a second capacitor.

In one embodiment, the first capacitor is tubular and extends about the second capacitor and the electrochemical device.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic perspective view of an energy storage device according to the invention;

Figure 2 is a cross section taken along line 2-2 of Figure 1;

Figure 3 is a schematic plan view of the configuration of the sheets used in the supercapacitor;

Figure 4 illustrates the sheets of Figure 3 in a wound configuration;

Figure 5 is a chart illustrating the discharge profile for a prior art battery and an energy storage device according to the present invention; and

Figure 6 is a schematic sectional view of a device according to another embodiment of the invention.

Referring to the drawings, and in particular to Figure 1 and Figure 2, there is illustrated an energy storage device 1. The device includes a cylindrical shrink wrap housing 2 having two opposed metal terminals 3 and 4. An electrochemical device in the form of a dry cell alkaline battery 5 is disposed within housing 2 for providing an electrical potential between the terminals. An electric double layer supercapacitor 6 is spirally wound and mounted to housing 2 and connected to terminals 3 and 4 in parallel with battery 5.

As shown in Figure 3, supercapacitor 6 is formed from two like opposed rectangular aluminium sheet electrodes 10 which are maintained in a spaced apart

overlying configuration by an intermediate separator 11. Each electrode includes a coating of activated carbon for providing a high surface area. Moreover, each electrode includes a protruding tab, which are separately numbered 15 and 16. The tabs includes respective central apertures 17 and are configured such that they protrude from opposite edges of the respective sheets.

The elements shown in Figure 3 are placed in a package with only tabs 15 and 16 protruding. An electrolyte is placed in the package before it is sealed. This arrangement is then spirally wound to provide the tubular supercapacitor 6, as best shown in Figure 4. The supercapacitor is hollow and extends axially between a first end 19 and a second opposed end 20. Each of the ends includes an aperture 21.

The internal diameter of the supercapacitor is such as to complementarily receive battery 5, which is inserted through one of apertures 21. Moreover, ends 19 and 21 are axially spaced apart to be co-terminus with the adjacent ends of the battery. That is, supercapacitor 6 provides a sheath into which battery 5 is received. Once so received, tabs 17 and 18 are folded across respective adjacent apertures 21 and welded or otherwise electrically connected to the battery terminals such that battery 5 and supercapacitor 6 are connected in parallel. In this embodiment use is made of ultrasonic welding. It will be appreciated that the positive terminal of battery 5 includes a detent which is received by and which extends through aperture 17.

Thereafter shrink wrap 2 is applied and device 1 is ready for use. It will be appreciated that device 1, when wound, has a total wall thickness of about 0.2mm. That is, device 1 only increases the diameter of the battery about which it is disposed by about 0.4 mm.

Supercapacitor 6 provides a capacitance of about 0.5 Farads and an ESR of 10 milliohms. Accordingly, device 1 offers performance characteristics which are far superior to that of battery 5 alone. That is, in situations where pulse loading of device 1 occurs, a predominance of the energy provided will be from supercapacitor 5. This reduces the pulse load on battery 5 and, as such allows the battery life to be extended. Moreover, between pulses battery 5 is able to recharge supercapacitor 6. That is, as the internal resistances of batteries are generally higher than the ESR or equivalent series resistance of a capacitor or supercapacitor the use of such a capacitor or supercapacitor in parallel with the battery reduces the effective resistance of the resultant energy storage device.

To better illustrate this, reference is made to Figure 5. The first curve, labelled 22, shows the discharge characteristic of three serially connected prior art dry cell primary batteries under a pulse load such as that provided by a GSM mobile telephone. The voltage provided by the batteries is dependent not only upon the remaining energy stored but also on the size and duration of the pulsed load. In addition, the internal resistance of a battery generally increases with decreasing energy stored. Thus there is a threefold effect. Firstly as a result of high power pulses the battery looses energy or capacity due to I^2R energy losses. Secondly, as the energy stored in the battery becomes depleted, the I^2R energy losses increase. Thirdly, the voltage provided at the battery terminals decreases due to the IR drop as a result of the increased internal resistance of the battery, the increasing IR drop with increasing resistance, and the decreasing energy stored.

In the chart of Figure 5, the minimum operating voltage for the particular application is 3 Volts. Insofar as the prior art device is concerned this minimum is reached quickly due to the three fold effect mentioned above.

An embodiment of the invention utilising series connected batteries of the same capacity, in parallel combination with respective series connected supercapacitors 6, provides the characteristic illustrated with curve 23. That is, the operational life of this embodiment is greater than that of the prior art as the I^2R losses, the voltage drop at the terminals of the device and the increase in battery internal resistance are less. This is a direct result of supercapacitor 6 working in parallel with battery 5 to supply most of the energy required by the individual pulses at the time of the pulse. This, in turn, occurs due to the lower ESR and large capacitance of supercapacitor 6 and the quantum of the energy drawn with each pulse. Due to the lower ESR of supercapacitor 6 the voltage drop across the energy storage device during the pulse is small and certainly less than that suffered by the prior art device illustrated in curve 22.

As the internal resistance of the battery is not now of such concern, the battery is configured for maximum energy density rather than maximum power density. The supercapacitor accommodates the power requirements of the load which allows the battery to be designed for maximum energy density. This combination also provides an extended life for the preferred embodiments in comparison to corresponding prior art devices.

In another embodiment, illustrated in Figure 6 where corresponding features are denoted by corresponding reference numerals, a device 30 includes an electrolytic capacitor 31. This additional capacitor extends axially away from one end of battery 5

and is sheathed within supercapacitor 6. Capacitor 31 is connected in parallel with both battery 5 and supercapacitor 6. While capacitor 31 has a much smaller capacitance and similar or smaller ESR to supercapacitor 6, it allows device 30 to accommodate extremely high frequency pulses without compromising the life of the battery.

Preferably, the external dimensions of device 30 correspond with the external dimensions of a prior art battery. For example, in one embodiment, device 30 has external dimensions of a AA battery, although the battery 5 utilised within the device is an AAA cell.

In other embodiments, supercapacitor 6 is disposed wholely within the existing housing of the battery. In other embodiments, battery 5 and capacitor 31 are utilised without supercapacitor 6.

The embodiments of the invention are particularly advantageously applied to pulsed load applications. Preferably, the ESR and capacitance of the capacitor or supercapacitor used in parallel with the battery are selected based upon the characteristics of the load. Accordingly, while general purpose devices are also constructed, the invention allows economical tailoring of energy storage devices to load specific applications.

Although the invention has been described with reference to specific examples it will be appreciated by those skilled in the art that it may be embodied in many other forms.

DATED this 13th Day of July, 1999

ENERGY STORAGE SYSTEMS PTY LTD

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Fellow Institute of Patent Attorneys of Australia
of BALDWIN SHELSTON WATERS

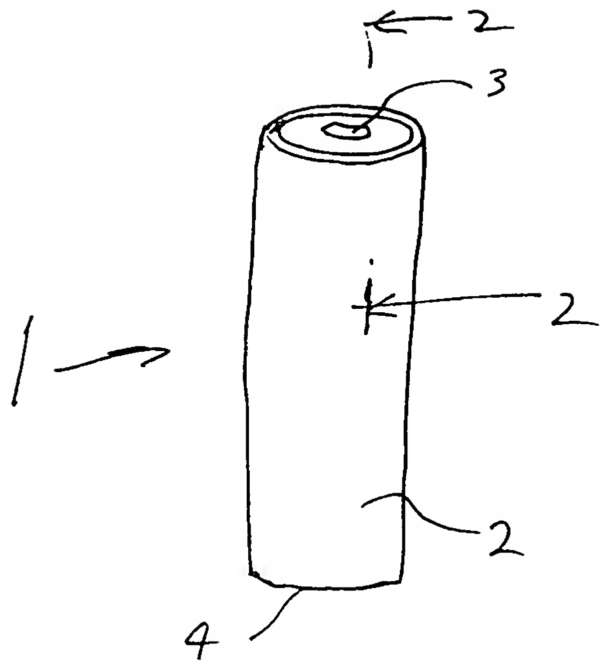

Fig 1

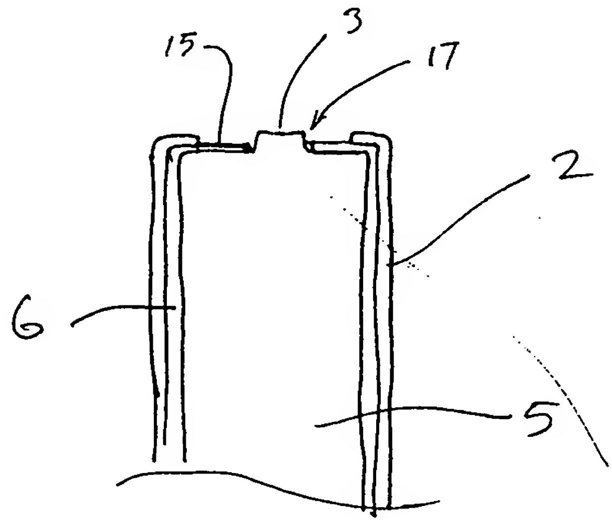

Fig 2

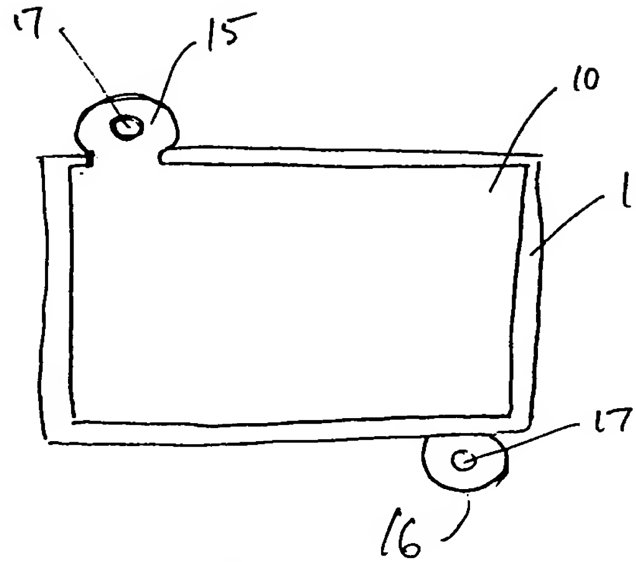

Fig 3

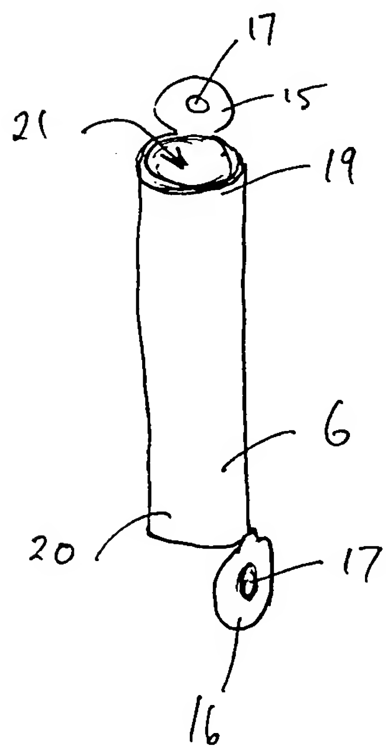

Fig 4

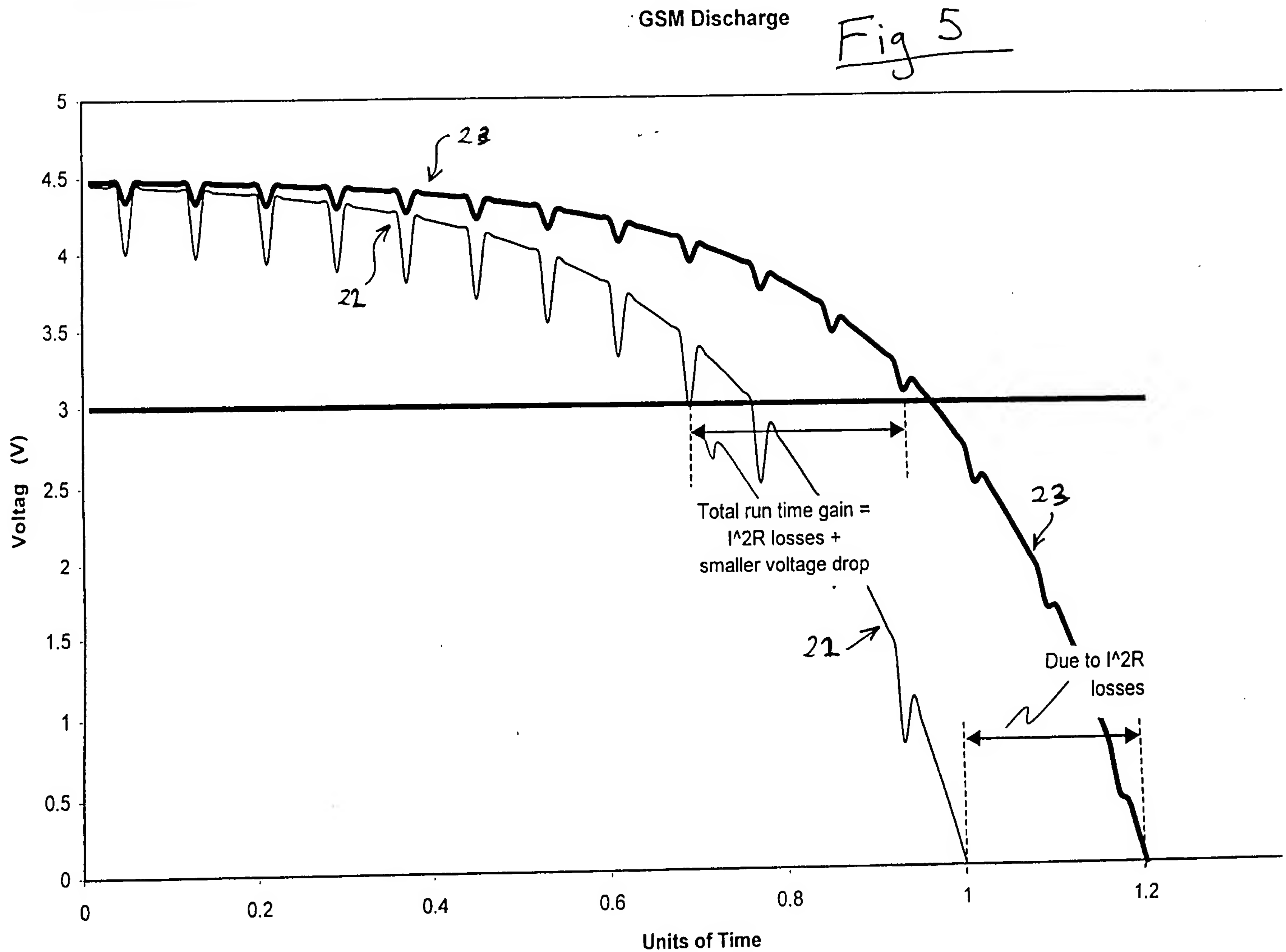
GSM Discharge
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Voltag (V)
0
0.2
0.4
0.6
0.8
1
1.2
Units of Time
23
22
Total run time gain =
I^2R losses +
smaller voltage drop
21
Due to I^2R
losses

Fig 5

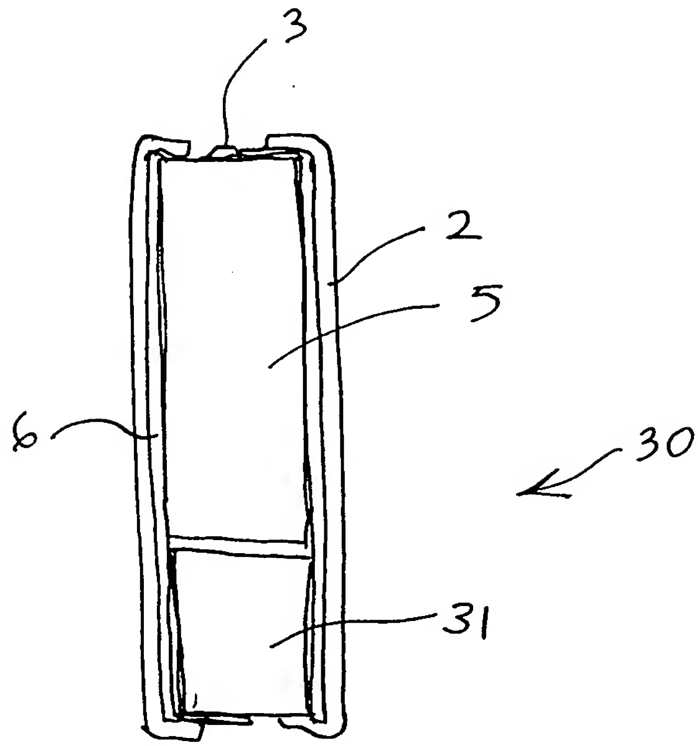

Fig 6.